MANITOBA CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

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MANITOBA

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WINNIPEG, MANITOBA

LOW ENERGY BERMED HOUSING

CARROLL RESIDENCE
SWAN RIVER, MANITOBA

MANITOBA/CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources - oil and natural gas - are becoming less accessible and more costly. However, Canada is well-endowed with non-renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of Manitoba and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement which was signed May 9, 1980 and terminates March 31, 1984. The Agreement is dedicated to the development and demonstration of conservation and renewable energy technologies. Equally cost-shared by the provincial and federal governments, the program has a total budget of $18-million.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies within Manitoba.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

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1. SUMMARY AND CONCLUSIONS

.1 Summary

The Carroll residence was surveyed on two separate occasions, once on July 20, 1981 and again on November 18, 1981.

The unique features of the home were observed on both occasions in terms of general comfort levels, appearance and general design, space temperatures and heating system operation.

On the initial visit, the air leakage rate of the structure was determined using an infiltrometer.

The objectives stated in the early stages of this project were as follows:

.1 To provide adequate comfortable living space with short term additional cost but long range economic payback as a result of energy conservation.

.2 To make use of Manitoba Hydro electric power as a major energy source with supplementing or complementing solar and wood heat.

.3 To make full and efficient use of energy by conservation techniques, including earth berms, maximum insulation, heat gathering atrium, air circulating ceiling fans and a wood burning heat circulating fireplace or stove.

.4 To provide a model and demonstration for contractors and the general public of the advantages of the techniques employed.

.5 To increase public acceptance of underground or semi-underground living space.

.6 To make maximum use of Manitoba's resources and encourage their greater use by others; these resources including hydro electric power, new developments in lumber products and our natural elements.

.7 To demonstrate the use of basic techniques of energy conservation which in the medium to long range are very economical and yet provide an aesthetic living environment and mentally assist the occupants in coping with our severe Manitoba winters.

.8 To remove the stigma attached to living below ground and the equation of it to living in a dark dingy basement by demonstrating how one can have maximum insulation and natural lighting at the same time.

.9 To attract greater public attention to the need for alternate energy sources and to the new or revised technologies to be considered in building and construction.

It is our opinion that the majority of the above objectives have been fulfilled. Assuming the public is made aware of this project, we would expect positive fulfillment of all listed objectives.

.2 Conclusions and Recommendations

Conclusions

Based on the information provided in this report, the bermed wall construction lends itself well to rural house construction, where land is relatively inexpensive. Within the city, bermed wall construction would likely not prove to be cost effective, as a result of smaller lot sizes, land-fill requirements, elevation of services, etc. Houses similar to the Carroll residence may be considered on some larger city lots.

While the atrium does provide a means of collecting solar energy, we do not feel that the amount of energy stored by the clay tile floor/earth storage mass provides any substantial benefit. During the winter, the floor is never exposed to direct sunlight, only to reflected light from the north wall of the atrium.

The energy efficient heat circulating fireplace (see Appendix E) is an excellent means of reducing energy costs, bearing in mind that wood is readily available at a lower cost than conventional fuel sources.

The circulating fan in the atrium when it is installed, will provide air circulation in the house. However, some doors may have to be left open to allow proper circulation. We cannot comment further on the effectiveness of this feature.

There are a number of factors which should be considered in determining the effectivenss of the construction techniques utilized in the Carroll residence. Some of the factors are as follows:

- the psychological effect of living underground
- the public acceptability of external aesthetics
- the availability of berming material
- the cost of construction relative to conventional techniques versus the return on investment.

Our opinion on the first two factors is that (a) the environment inside the house is such that there is no feeling of living underground. The daylight allowed into the house through the atrium provides the effect of above ground living, (b) the building, landscaping and external features are certainly aesthetically pleasing.

The availability of berming material and the cost/benefit of construction would need to be evaluated on an individual basis.

In conclusion, it is apparent that the Carroll's adaptation of an Amercian energy efficient home design to the Canadian climate is proven effective without major alterations to the original design.

Recommendations

The Atrium Passive Solar Heating and Earth Mass Storage could be improved by using the wall for storage instead of the floor. A dark wall, with some substantial mass (creating a Trombe wall effect) with the suns' rays hitting it directly would be a more effective means of storing heat.

The atrium will allow a considerable heat build-up in the summer unless some form of shading is provided. We would recommend a thermal insulating blind, operable from inside the atrium. This would allow a reduction of heat loss from the atrium in the winter during periods when passive solar energy is not being collected.

The individual room temperature control should be utilized as much as possible - rooms not being used should be maintained at lowered temperatures. The electric heat will provide a quick and efficient means of heating rooms to the required temperature when needed.

As electrical energy is not separately metered for heating, domestic hot water and general use, it is not possible to determine the exact energy use for each of the individual requirements. It is possible to estimate these requirements; however, if more accurate information is required it could be obtained by the installation of sub-metering equipment. To enable specific monitoring of energy use, we would recommend that sub-metering be installed to meter the electric heating, domestic hot water heating and lighting separately.

2. RÉSUMÉ ET CONCLUSIONS

.1 Résumé

La résidence des Carroll fut examinée à deux reprises différentes, une fois le 20 juillet 1981 et ensuite le 18 novembre 1981.

Au cours des deux visites, les caractéristiques distinctives de la maison furent considérées par rapport aux facteurs suivants: le confort, l'aspect et le plan général, les températures et le système de chauffage.

Lors de la première visite, on détermina le taux d'infiltration d'air en se servant d'un infiltromètre.

Les objectifs définis au cours des premiers stades du projet furent les suivants:

.1 Assurer de façon satisfaisante le chauffage d'une résidence avec des débours qui seront plus élevés pour commencer mais qui, grâce à la conservation de l'énergie, permettront à la longue des économies appréciables.

.2 Se servir du courant électrique d'Hydro Manitoba comme source principale d'énergie avec chauffage supplémentaire ou complémentaire à l'énergie solaire et au bois.

.3 Utiliser l'énergie intégralement et efficacement grâce aux techniques de conservation comprenant: la construction semi-souterraine, l'isolation maximale, une verrière de toiture pour capter la chaleur, des ventilateurs suspendus, une cheminée ou poêle à bois à chaleur rayonnante.

.4 Fournir un modèle qui permettra de démontrer aux entrepreneurs et au grand public les avantages des techniques employées.

.5 Favoriser l'approbation du public pour les résidences souterraines ou semi-souterraines.

.6 Utiliser les ressources du Manitoba au maximum et encourager les autres à s'en servir plus; ces ressources comprennent le courant hydro-électrique, les nouveaux produits du bois et les éléments naturels.

.7 Démontrer les techniques essentielles de la conservation de l'énergie; ces techniques sont très économiques à moyenne échéance ou à longue échéance et, cependant, elles contribuent à créer un environnement esthétique et, sur le plan psychologique, elles encouragent les occupants à supporter les rudes hivers du Manitoba.

.8 Détruire les préjugés qui s'appliquent aux gens qui vivent sous terre et, par analogie, à ceux qui demeurent dans des sous-sols obscurs, en démontrant comment on peut bénéficier du maximum d'isolation et d'éclairage en même temps.

.9 Faire de plus gros efforts pour attirer l'attention du grand public sur la nécessité de trouver des sources d'énergie de remplacement et sur les technologies nouvelles ou révisées de construction.

Nous croyons que la plupart des objectifs ci-dessus ont été atteints. Si l'on assume que le public est tenu au courant de ce projet, on peut s'attendre à ce que tous les objectifs ci-dessus soient atteints de façon positive.

.2 Conclusions et recommandations

Conclusions

D'après l'information contenue dans ce rapport, la construction semi-souterraine est à recommander dans les régions rurales où le terrain est relativement bon marché. Dans les villes, ce procédé serait moins économique à cause des terrains plus petits, des règlements sur les travaux de terrassement, du niveau des services, etc. La construction de maisons semblables à celle des Carroll pourrait être envisagée sur des terrains urbains plus grands que la moyenne.

Bien que la verrière du toit constitue un moyen de capter l'énergie solaire, nous ne pensons par que l'énergie soit emmagasinée en quantité suffisante par le carrelage d'argile et le mur de maçonnerie lourde pour permettre des économies appréciables. En hiver, le carrelage n'est pas exposé à la lumière solaire; il ne reçoit que la lumière réfléchie par le mur septentrional de la verrière.

Le rendement énergétique élevé de la cheminée à chaleur rayonnante (Appendice B) permet efficacement de réduire le coût de l'énergie, considérant que le bois est disponible plus facilement que les sources ordinaires de combustibles et à meilleur marché.

Une fois installé, le ventilateur de la verrière du toit permettra à l'air de circuler dans la maison. Toutefois, il faudra laisser des portes ouvertes pour faciliter une circulation d'air appropriée. Nous n'avons pas d'autres commentaires à faire sur l'efficacité de ce dispositif.

En vue d'évaluer l'efficacité des techniques de construction utilisées dans la maison des Carroll, il faudra considérer un certain nombre de facteurs, à savoir:

- l'effet psychologique créé par la vie souterraine,
- les réactions du public devant l'esthétique externe.
- la disponibilité des matériaux de construction semi-souterraine.
- le coût de la construction par rapport aux techniques ordinaires dans le cadre du revenu produit par le capital.

En ce qui concerne les deux premiers facteurs, nous sommes d'avis que (a) l'ambiance intérieure ne donne pas l'impression qu'on vive sous terre. La lumière du jour qui entre dans la maison par la verrière du toit donne l'illusion qu'on vit au-dessus du niveau du sol, (b) la construction, l'aménagement du terrain et les caractéristiques extérieures sont certainement agréables au point de vue esthétique.

La disponibilité des matériaux dans la construction semi-souterraine et le rapport coût/profit devront être évalués séparément dans chaque cas.

Nous en concluons que l'adaptation au climat canadien d'une maison américaine à faible consommation énergétique telle que la résidence Carroll nous apparaît comme un projet valable ne nécessitant pas de modifications importantes au plan original.

Recommandations

Le chauffage solaire actif de la verrière d'une toiture et le stockage dans une masse thermique pourraient être améliorés si on se servait du mur au lieu du carrelage pour accumuler l'énergie. Un mur sombre de maçonnerie lourde (pour créer l'effet de Trombe) et exposé directement aux rayons du soleil constituerait un moyen plus efficace d'emmagasiner la chaleur.

En été, la verrière du toit provoquera une augmentation considérable de la chaleur à moins qu'on puisse trouver un moyen de la mettre à l'ombre. Nous recommandons l'emploi d'un rideau d'isolation thermique qu'on puisse manoeuvrer sous la verrière. Cela permettrait une diminution des pertes de chaleur dans la verrière au cours des périodes hivernales où l'énergie solaire passive n'est pas captée.

Dans la mesure du possible chaque pièce devrait être munie d'un thermostat indépendant - les pièces non utilisées devraient être maintenues à de plus basses températures. En cas de besoin, le chauffage électrique permettra de hausser rapidement et efficacement la température des pièces au niveau voulu.

Étant donné qu'on ne relève pas séparément la consommation électrique pour le chauffage de l'eau d'une maison et pour l'usage général, il n'est pas possible de déterminer exactement la quantité d'énergie utilisée pour chacun des usages domestiques. Il est possible de faire des estimations; toutefois, si on a besoin de données plus précises, on peut se servir de compteurs secondaires. Afin de permettre le contrôle précis de l'énergie utilisée, nous proposons qu'on emploie des compteurs secondaires pour mesurer séparement le chauffage électrique, le chauffage de l'eau d'une maison et l'éclairage électrique.

2. SCOPE OF WORK AND BUILDING LOCATION

.1 Scope of Work

We were contracted to evaluate the effectiveness of the construction techniques used in the Carroll Residence.

Our efforts were to concentrate on the unique energy saving features of this home, i.e. bermed wall, atrium, passive solar heating and air circulation. Tests and observations were to be undertaken to:

.1 observe general comfort levels

.2 observe appearance and general design

.3 determine air infiltration

.4 observe temperatures and heating system operation.

A final report to be prepared consisting of the following:

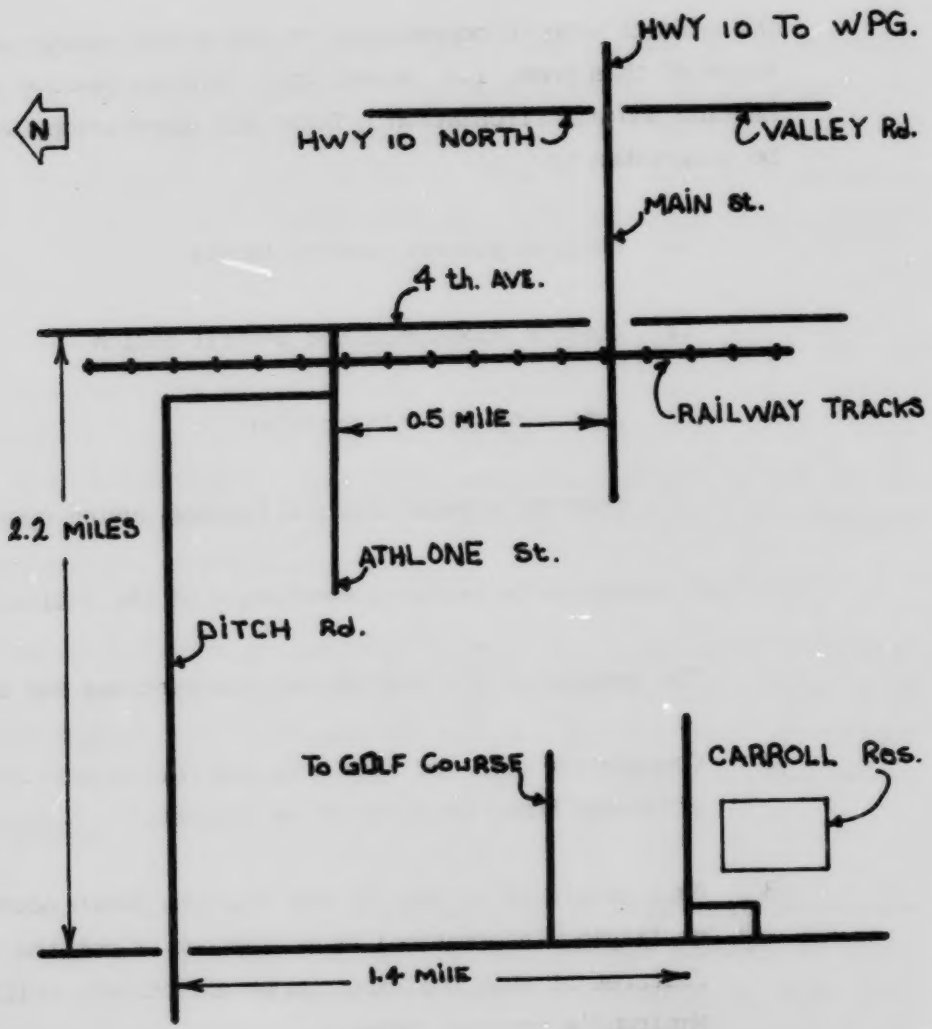
.1 The results of our monitoring, observations and evaluation.

.2 Comparative data for this home and more conventional energy efficient homes being built at present.

.3 As a result of .1 and .2, our opinion, (with necessary qualifying information) as to whether or not the unique features of this building can be effectively utilized in Manitoba's housing industry.

.2 Location and Map

Swan River is located north - north west of Winnipeg at a distance of approximately 315 miles. The following map shows the location of the Carroll residence in relation to Swan River and Winnipeg.



3. BUILDING DESCRIPTION

.1 General

The Carroll residence in Swan River, Manitoba is an executive home which utilizes energy conserving features while still maintaining a very comfortable environment for its occupants.

Mr. and Mrs. Carroll chose an American energy efficient design as the basis for building their home. The single storey structure displays interesting and unique features, both architecturally and functionally. Refer to Appendix G for building floor plan.

.2 Building Areas

The gross floor area of the residence is 297 square metres, including a 36 square metre atrium.

The gross exposed outside wall area of 92.5 square metres includes 8.5 square metres of sealed triple glazed windows. The gross bermed outside wall area is 72.5 square metres. The roof of the atrium has glazing on the south exposure totalling 12.6 square metres.

.3 Exterior Walls

The exterior wall surface is finished with dark brown cedar siding, roofing is dark brown shingles. Since dark colours absorb heat from the sun, the effective indoor to outdoor temperature difference will be reduced during periods of sunshine, resulting in a lower heat loss.

.4 Bermed Walls

The bermed wall construction and landscaping in the immediate vicinity of the house are integral parts of the architectural design, as well as being functional. The majority of the outside wall surface area is bermed with sand, then landscaped. This effectively reduces the temperature differential throughout the year, which in turn reduces the energy requirements for heating and cooling. The berm also provides protection from prevailing winds and precipitation and minimizes exterior maintenance requirements for the home.

.5 Windows

Triple glazed windows are located flush with the exterior wall surface which reduces snow build-up on the sills in the winter, allows for more decorative interior window design and reduces heat loss through the glass (as a result of 'still' air next to the interior glass surface).

.6 Insulation Levels

The insulation levels in the Carroll residence are well above those recommended by the 1978 Manitoba Building Code, which required R-33 in the ceiling, R-12 in the walls and R-7 to 2 feet below grade. Levels are, however, consistent with many super energy efficient houses recently constructed.

The ceiling is insulated with 300 mm of loose - fill insulation with an R.S.I. value of 7.7 (R-44). Fibre glass insulation to a thickness of 200 mm is used in the exterior walls for an R.S.I. value of 5.28 (R-30). Insulation is carried down below the main floor level to the concrete footings.

.7 Utilities

The property has its own water supply and septic field. Electricity is provided by Manitoba Hydro.

4. HEATING SYSTEMS

.1 Atrium

There is a large atrium in the centre of the house, with windows located on all but the north roof. The atrium floor consists of dark clay tile on concrete over a large earth mass - the floor is intended to act as solar - storage. In addition to being the primary heating source for the building, the atrium provides an excellent source of natural light for the occupants. This is intended to eliminate the psychological effects of living underground.

.2 Secondary and Tertiary Systems

There are two back-up heating systems in the building. The secondary system is an energy-efficient wood-burning heat circulating fireplace and the tertiary system consists of individual room temperature controlled electric baseboard radiation and force-flo unit heaters.

5. LANDSCAPING

Deciduous trees to the south provide shade in the summer and allow for passive solar heating during the colder weather.

6. OBSERVATIONS, TESTS AND MONITORING

.1 Observations

We visited the Carroll residence during the week of July 20, 1981. The average outdoor air temperature was 20 deg. C (68 deg. F). During this site visit, the following observations were made.

.1 Several items of construction were yet to be completed, as follows: window framing, electric heating, tile and floor covering, atrium walls, circulating fan, fireplace.

.2 It was generally cool throughout the house, which would indicate that the bermed walls are effective in keeping the home cool in the summer.

A second site visit was conducted on November 18, 1981. The average outdoor air temperature during the visit was -5 deg. C (23 deg. F).

Observations were as follows:

.1 The house was found to be generally comfortable throughout, with few 'cold spots' and no drafts. The air quality was quite good and there was no feeling of 'stuffiness' to suggest poor ventilation. Very few interior doors, including the doors on the atrium, had been hung and the circulation of air will certainly change when the interior is complete. Complete circulation of air will demand that the doors of the atrium be left open for a good part of the day. This may be a problem on those days when the atrium is receiving very little light and is therefore quite cool.

.2 Lighting levels were adequate within the house, with a large proportion of the light coming from the central atrium. The atrium works well in this regard.

Temperature differences throughout the house were minimal, suggesting perhaps that low-use areas such as the utility room, storage, etc. were being heated at the expense of warmer areas - living room, etc.

.3 The entry has a small force-flo heater with integral thermostat that generally comes on when the front door is opened, maintaining a comfortable temperature. Nevertheless, this area will be quite cool in the winter and it is suggested that the doors leading off of it be kept closed as much as possible. Warm air from the atrium could easily be lost by carelessly leaving the door between the entry and atrium open. In addition, there may be a temptation to use the atrium as a storage space for shovels, boots, lumber etc. and the constant opening and closing of that door and the outside door could lead to considerable heat loss.

.4 All exterior windows are triple glazed thermal panes mounted flush to the exterior wall. The largest single glass area - the sliding door on the east side of the family room - fits well into a plastic weather moulding and there is no noticeable draft around its edges. The indoor face temperature of the doors was suprisingly high 15.5 deg. C; (60 deg. F) and other windows felt similar. Mrs. Carroll plans to install quilted thermal blinds over bedroom windows to futher reduce heat loss.

.5 Windows on the atrium are double glazed, as will be the doors not yet installed.

.6 The fireplace materials were on site but not yet installed. The fireplace has an electric fan blower to circulate room air and is vented with 50 - 100% outside air for combustion. Outside air is brought in through a well insulated duct that runs vertically off the fireplace and will probably be pre-heated by chimney heat before it enters the combustion area.

The fireplace is to be the house's primary source of fresh air and there is very little fresh air entering through other vents in the house.

.7 The crawl space is heated by two electric heaters and is maintained at a relatively high temperature 19 deg. C (66 deg. F). There are small air vents in it that have been insulated and capped for the winter but will be opened in summer.

.8 The ceiling fan and doors have yet to be installed in the atrium so the effectiveness of the atrium for heating and air circulation is not known. The area has a large force-flo heater on the north wall, and the Carrolls plan to install 2 more heaters of either this or the baseboard type along the east and west walls.

The most significant observation in the atrium was that the sun never gets below half way down the north wall and this can be assumed to be the case for the majority of the heating season. On the other hand, the sun will shine directly on the floor during the summer months and for a considerably greater part of the day. The effect should be that the atrium is underheated in winter and overheated in summer with the current arrangement of light walls and dark floor. The Carrolls believe that the light coloured walls will reflect the sunlight on to the darker floor in winter - increasing the heating effect - and that sufficient shade will keep the atrium floor from overheating in the summer.

The glass on the atrium roof was partially snow covered as a result of a light snowfall the previous night. Heavy snowfall or ice rains could be expected to greatly reduce the effectiveness of the window. The only solution is to manually clear the glass as this situation arises.

.2 Testing and Monitoring

.1 General

Tests were undertaken as follows:

.1 Air leakage into the house was measured at various simulated outdoor wind conditions.

.2 Indoor wall surface temperatures were measured and recorded for both the bermed and exposed exterior walls.

.3 Temperature and humidity level in the house were measured and recorded.

Equipment used for the above measurements is listed below.

.1 To measure air leakage: An Infiltrometer.

.2 To measure wall surface temperatures: An Alnor Pyrocon.

.3 To measure temperature and humidity levels: A sling psychrometer.

.2 Air Infiltration Testing

It is not unusual for air infiltration in conventional houses to account for up to half of the total building heat loss.

The Minnedosa firm of D.R.S. Enterprises Ltd. was hired to test for air leakage at the Carroll residence. The equipment used is described in Appendix A.

Two tests were conducted. The first test was basically done to locate the areas of large air leakage. It was determined from this test that the sources of major air leakage were the following:

.1 a break in the vapour barrier at the four corners of the atrium.

.2 wall plugs and switches on interior and exterior walls.

.3 light fixtures.

.4 between vapour barrier and window openings.

.5 around fresh air duct to fireplace.

.6 across the top of the patio door.

The second test was conducted after some of the sources of air leakage found in the first test were temporarily patched.

This second test procedure produced more accurate and realistic results with a reduced air leakage surface area from .35 square metres (1.15 square feet) in test no. 1 to .014 square metres (.38 square feet) in test no. 2 - a reduction of some 67%.

The infiltrometer test results were based on two different test pressures: an indoor negative pressure of 50 Pascals, simulating an indoor wind condition of 12.5 /h kilometers per hour (20 mph) and an indoor negative pressure of 4 Pascals, simulating normal average annual wind conditons.

At 50 Pascals the air change rate measured by the infiltrometer was 2.482 air changes per hour. At 4 Pascals, this dropped to .417 air changes per hour.

The results of the infiltrometer test can be compared with similar tests conducted on a variety of other homes. Graph No. 1, Appendix A, shows the air change rate at various simulated wind conditions. Note that the Carroll residence curve falls between the family of curves for super energy efficient homes and Curves A and B which represent typical energy efficient home construction.

The levels of infiltration indicated on the curves lead us to conclude that the Carroll residence allows less leakage than the average home built with energy conservation in mind. It should be noted, however that the house was not fully completed at the time of testing. As a result, we would expect a further reduction in infiltration from that tested.

.3 Surface Temperature Testing

During our original site visit, of July 20, 1981 surface temperature measurements were taken at three different wall heights for various walls. The results of these measurements are shown in Appendix B.

Due to the fact that the outside temperature was 20 deg. C (68 deg. F), the measurements taken did not allow us to form any conclusion regarding the bermed versus unbermed wall construction.

As well, the day was cloudy and no conclusive results were obtained regarding the efficiency of the atrium in collecting solar heat.

During our second site visit of November 18, 1981 surface temperature measurements were again conducted, the results of which are shown in Appendix B.

.4 Temperature and Humidity Levels

During our initial site visit the indoor dry bulb and wet bulb temperature, measured with a sling psychrometer, were as follows:

Dry bulb	20.8 deg. C (69.5 deg. F)
Wet bulb	16.9 deg. C (62.5 deg. F)

These measurements result in a relative humidity of 68%. These measurements coincide with the outdoor temperature and humidity levels of 17.8 deg. C (64 deg. F) and 70% relative humidity.

During our second site visit, we again recorded temperature and relative humidity. There was a considerable variation in these readings from room to room, as shown in Appendix B.

7. COMPARATIVE EVALUATION

It is interesting to compare the Carroll residence to conventional homes and to other energy efficient homes. To assist in our comparison, we have, in Chart No. 1, Appendix C charted the various parameters for the following homes.

.1 The Manitoba Hydro Super Energy Efficient House (SEEH)

.2 The 1980 Canadian Energy Association Standards (1980 CEA)

.3 The 1978 Manitoba Building Code (1978 MBC)

.4 The Saskatchewan Coservation House (SCH)

.4 The Saskatchewan Coservation House (SCH)

.5 The Manitoba Energy Efficient Flair Home - Project #3 (FH#3)

.6 The Manitoba Energy Conservation House (MECH)

The air change rate has been discussed in detail earlier. It is sufficient to note here that the infiltration measured for the Carroll residence is lower than that required by the 1978 MBC. However, it is substantially higher than SEEH and SCH.

The calculated annual energy usage for the Carroll residence is compared with three other homes as shown below.

	kWh per sq. ft. per year	GJ per sq. m. per year
Carroll Residence	4.24	.16
SEEH	2.98	.11
CEA	9.68	.37
MBC	17.87	.68

NOTE: Basement areas are included in analysis.

As seen in the above analysis, the Carroll residence is expected to fare quite well when compared to other energy efficient homes.

The calculated design heating load of 7.7 kW is based on areas and physical parameters given in Appendix D - Calculations.

The insulation levels in the Carroll residence are better than the 1980CEA and the 1978 MBC requirements. However, the higher levels in other energy efficient homes were not achieved.

In general, the construction and design of the Carroll residence from the viewpoint of energy use are well above those of conventional homes. As seen in the comparison chart, other energy efficient homes also utilize air to air heat exchangers, waste water heat re-utilization, etc. which effectively reduce energy usage beyond that in the Carroll residence.

APPENDIX A

INFILTROMETER RESULTS AND INFORMATION

ENER-SEAL

INFILTROMETER TEST RESULTS

VOL/AREA

810.	M↑3 *	
311.	M↑2 **	

* volume of house in cubic meters
** exposed surface area in sq. meters

TEST I RESULTS
H. PRS/N. PRS/FLOW

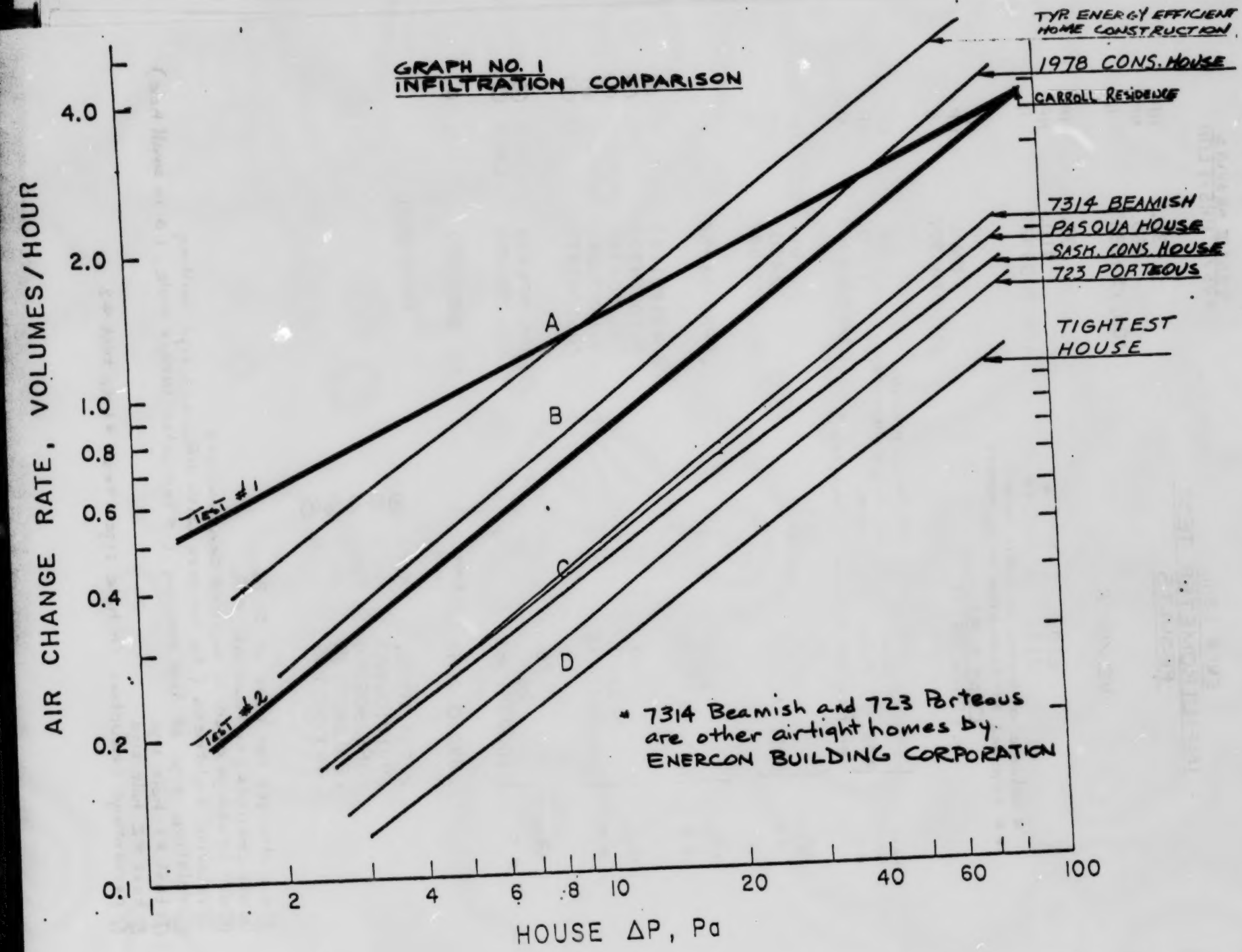
FAN SPEED #1	22.	HP	house pressure
	800.	NP	nozzle pressure
	442.0007556	Q	air flow out of house (litres/sec.)
SPEED #2	27.	HP	
	1050.	NP	
	507.6439112	Q	
SPEED #3	51.	HP	
	1560.	NP	
	621.0243599	Q	
SPEED #4	70.	HP	
	2400.	NP	
	773.3447733	Q	
SPEED #5	76.	HP	
	2630.	NP	
	810.2351081	Q	
	.9901002652	CORR. COEFF.	
	2.901709501	50PA	ⓐ
	.9010106405	4PA	ⓑ
	1066.906988	CM↑2	ⓒ
	.6518609135	MM/S	ⓓ
	.4630501243	N	ⓔ

TEST II RESULTS
H. PRS/N. PRS/FLOW

32.	HP	
660.	NP	
400.7512205	Q	
38.	HP	
910.	NP	
471.9009927	Q	
50.	HP	
1260.	NP	
557.0295977	Q	
62.	HP	
1670.	NP	
642.9404328	Q	
80.	HP	
2450.	NP	
781.5071587	Q	
.9980154257		
2.481751169	50PA	ⓐ
.4170074953	4PA	ⓑ
352.504365	CM↑2	ⓒ
.3016935256	MM/S	ⓓ
.7061785971	N	ⓔ
1066.906938	CM↑2	ⓕ
352.504365	CM↑2	ⓖ
66.96015969	%	ⓗ

ENER-SEAL

ⓐ air changes per hour at 50 Pa
ⓑ air changes per hour at 4 Pa
ⓒ air leakage area in square centimeters
ⓓ relative tightness (to compare with different size building
ⓔ relative size of the opening (.5 indicates larger hole, 1.0 is small hole)
ⓕ test #1 hole size
ⓖ test #2 hole size
ⓗ percentage reduction in hole size - test #1 to test #2


GRAPH NO. 1
INFILTRATION COMPARISON
TYR. ENERGY EFFICIENT HOME CONSTRUCTION
1978 CONS. HOUSE
CARROLL RESIDENCE
7314 BEAMISH
PASQUA HOUSE
SASK. CONS. HOUSE
723 PORTEOUS
TIGHTEST HOUSE
A
B
C
D
TEST #1
TEST #2
* 7314 Beamish and 723 Porteous are other airtight homes by ENERCON BUILDING CORPORATION
AIR CHANGE RATE, VOLUMES/HOUR
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
1
2
4
6
8
10
20
40
60
100
HOUSE ΔP, Pa

The following technology is about to revolutionize an entire industry. With you. Or without you.

The research is over. The testing complete. And what was once mere suspicion is now documented fact: air leakage is now regarded as the most significant source of heat loss in most structures.

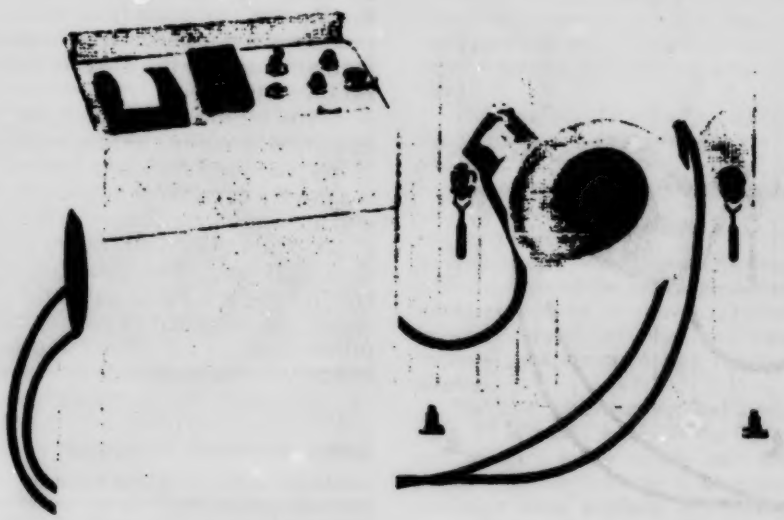
Already, the government of Sweden has established minimum standards for air leakage rates in new construction. Already, the United States has recognized air leakage in model building codes.[1]

And the bottom line?

Simply put, if you're not equipped to measure, remedy, and document reduced air leakage rates, you're not equipped for the future.

ener-corp

THE ENERGY MANAGEMENT COMPANY



Introducing the Infiltrometer.*

The Infiltrometer was developed by Ener-Corp Management Limited based on research and technological advances made by the National Research Council of Canada. Once mounted in an exterior door opening, the Infiltrometer creates a vacuum or negative pressure inside the building. Its micro-electronic Control Centre then calculates, quantifies, and records the exact amount of air then infiltrating the structure. Both primary and secondary (otherwise undetectable) sources of leakage are then sealed.

Sealing complete, the Infiltrometer then re-measures air leakage rates, and the Control Centre calculates and records on a digital print-out the exact amount by which the original leakage rate has been reduced. By percentage. In writing. Guaranteed.

As a natural complement to the Infiltrometer, we have also developed a unique Moisture and Air Control unit (MAC 1000) which humistatically expels stale, humid air from the structure, and replaces it with fresh, dry air while significantly minimizing the amount of heat energy lost in the exchange.

The Infiltrometer, its computerized Control Center, and specialized sealing & caulking equipment are available with an intensive 3-day training program on operations, installations, materials, marketing and back-up services. A proven investment whose return, even within the first year, can approach 100%. The licensed dealer program also includes the MAC 1000, and an exclusive line of premium caulking and weather-stripping products.

Give it some thought, but keep this in mind: we're not talking about another new product, or another new service. We're talking about an entirely new, independent, and lucrative market within an industry that badly needs one. We're talking about credibility: the unprecedented ability to scientifically verify a reduction in the most significant source of heat loss. We're talking about the future.

With you. Or without you.

Dealer enquiries, contact Bob Saull, Vice President

[1] Uniform Building Code, Sec. 5302 (e)

* patents and industrial protection designs pending

ENER-CORP MANAGEMENT LIMITED 2 Donald Street, Winnipeg, Manitoba R3L 0K5 (204) 477-1283

"Air Leakage and the Infiltrometer"

The importance of reducing uncontrolled air leakage in residential dwellings cannot be over-emphasized. It is the major component of heat loss in almost every home in North America.

The Canadian Government has recently established a committee on Airtightness of Buildings, charged with the responsibility of developing an airtightness standard for residential construction. The National Research Council of Canada has recognized the importance of airtightness in a number of its publications.[1]

A number of research organizations in the United States have drawn some startling conclusions in the air leakage work they have been involved in. Princeton University, for instance, have determined that "...house-to-attic warm air leaks...result in the waste of almost 20% of all the home heating energy (2% of all energy) used in the United States. That is equivalent to wasting over 600,000 barrels of oil a day."[2]

Lawrence Berkeley Laboratory have concluded in one of their publications[3] that "for homes in the United States...air leakage imposes a 30% to 40% burden on the energy load of a typical house."

Based on air leakage measurement practices developed in Sweden, the American Society for Testing and Materials (ASTM) has proposed a standard for air leakage measurement by the fan pressurization method.

The Infiltrometer has been designed to exceed all requirements of the proposed standard. The result is a device capable of automatically and accurately determining the air change rate of virtually every single detached residential structure in North America. Field data and results are recorded by an electronic printer to add a significant degree of integrity to this sophisticated device.

Copies of the above-noted publications and other informational data is available on request.

ener·corp

THE ENERGY MANAGEMENT COMPANY

Call Toll Free

1-800-228-2606

24 hours a day—7 days a week

1. HANDEGORD, G. O., The Need for Improved Airtightness in Buildings, National Research Council of Canada, Division of Building Research, Building Research Note No. 151.
2. DUTT, G. S., If Home Energy Saving is such a Good Idea, Why don't more People do it?, Appendix A, Centre for Energy and Environmental Studies, Princeton, University.
3. GRIMSRUD, D. T., et al., Calculating Infiltration: Implications for a Construction Quality Standard, Energy and Environment Division, Lawrence Berkeley Laboratory.

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EASTERN CANADA: 440 St. Joseph Boulevard, Hull/Ottawa J8Y 3Y7 (819) 777-4446
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Sealing the Building Saves the Heat

By Donald L. Aiken

Infiltrometer" may never become a household word to the general public, but it's likely to be a common term for energy conservers and insulation specialists in the very near future.

The infiltrometer is a machine developed in Winnipeg to perform a vital function in dras ically reducing heating costs in both homes and commercial or industrial buildings. It was the logical outcome of the operations, thought and research carried out by a Winnipeg company, Ener-Corp Management Limited, whose name has become well-known to local newspaper readers for a series of advertisements designed to educate and warn readers about insulation.

The present management of Ener-Corp took over the business in October, 1979, and since then has been devoting a major portion of its activities to research and educational programs.

The infiltrometer is, basically, a device to measure the rate at which outside air enters a building. Almost all structures admit and emit air through minute crevices, windows and doors. In winter, heat escapes and cold enters, and the rate of air change may be as much as 1.2 to 1.5 changes per hour.

The infiltrometer measures this rate, and the operator, using a draft-detecting device, can then pinpoint the location of air leakage. By caulking, weatherstripping and sealing, the air change rate can then, Ener-Corp says, be cut by at least half.

"We expect business through credibility and performance."

The prototype infiltrometer built by Ener-Corp is the only one of its kind, but the company is preparing to manufacture the device for nation-wide use.

"Sealing a building is most important to reducing heat loss and energy waste," said R.K. (Bob) Saull, marketing vice-president of Ener-Corp. "You can put R40 insulation in a poorly sealed building and your heating cost will still be more than in a well-sealed structure with only R10 insulation."

Ener-Corp has run tests on three homes and is starting a 100-home test program intended to demonstrate the effectiveness of the project. A provincial government grant of $35,000 has been made available to enable an independent engineering firm to analyse and verify the results of the test program.

The company plans to monitor a full heating season of homes which have been sealed as a result of the infiltrometer check, and the results will then be converted to show a dollar figure on heating economy.

"We're excited," said Saull, "over some of the steps government is taking in this area. A standards board has been finalized in which the insulating industry, materials manufacturers and government will operate a program including manuals, training for sales and work crews and testing procedures.

"A course is now in progress at Red River Community College providing the instruction required for this kind of work, and a 70 per cent mark is required to pass written and practical examinations."

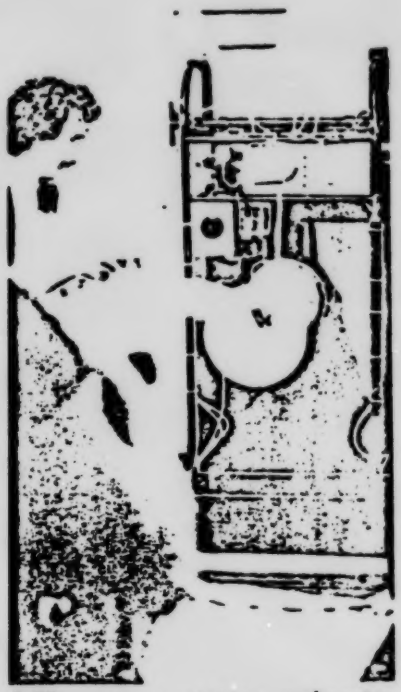
There will also be a fee for certification of trainees — $250 per employee — and a $10 a job inspection fee. And, as further protection for the consumer, only certified companies will be eligible for government grants.

Ener-Corp's educational program took the form of the newspaper advertisements referred to above, in which various aspects of the insulation business were discussed in a full-page display.

The first advertisement was forthright. "The public image of the insulation industry today simply isn't that positive," it stated bluntly. It referred to confusion about products and installation and added that because the industry had grown suddenly and quickly, it "has attracted its fair share of unknowledgeable and even irresponsible contractors."

That first ad then outlined the topics of the rest of the series — The $30 Attic; Air Infiltration; Ventilation; Insulation Products; Contractors; The Government.

After the first three listed, the company ran an ad saying "We've pulled the government ad," and telling readers why.



Infiltrometer prototype undergoing tests.

"This series was intended to show our great concern for the reputation of the industry and to educate and warn consumers about the pitfalls in many insulating advertisements," said Saull. "And we've had a great response to the ads. They're not a 'Buy Me' type of marketing but intended for the long term.

"We expect business through credibility, and intend to get this through performance."

When they entered the industry, Saull and company president Wayne Cole found that there was a good deal of what they call gimmickry as well as strong dependence on government grants and similar things.

Several Ontario firms had come into Manitoba, adopted new names, offered piecework rates to crews and tried for the highest possible government grants.

"Salesmen were promising anything just to get the orders," said Cole.

Ener-Corp salesmen felt frustrated because, while they are trained and instructed to stay within rigid guidelines as to prices and services, other companies'

(Continued on Page 46)

APPENDIX B

TEMPERATURE MEASUREMENTS

TEMPERATURE TEST (^{o} F) July 20, 1981

WALL	LOCATION	FLOOR LEVEL	3.5'	5.5'
Living Room (Bermed)	West	17.2 (63)	17.8 (64)	(64)
Living Room (Bermed)	South	63	64	(64)
Family Room (Bermed)	South	17.5 (63.5)	64	18 (64.5)
North-West Corner		NO LIGHTING AVAILABLE		
North-East Corner (Bermed)	East	64	64	64
North-East Corner (Bermed)	North	17.5 (63.5)	64	64.5
Atrium	North	64	65	18.3 65
Atrium Floor		64		

At time of test outside temperature was 68^{o} F. Construction was going on and no heat was provided into the house. It was a cloudy day. Temperature inside was 66^{o} to 68^{o} F. It appears that during sunny day inside temperature stays low where as atrium temperature increases substantially. Therefore it seems that bermed walls are effective in summer. One problem arise: what to do with heat of atrium in summer - could consider using a heat pump to provide cool air in summer - (Temperature of house is cool, but comfortable with clothes).

RELATIVE HUMIDITY TEST (^{o} F)

	AFTER
DRY TEMPERATURE	69 - 69.5
WET TEMPERATURE	62 - 62.5

The test was done in the atrium. The atrium had no door or any other rooms in house. Therefore it is estimated that conditions were the same in the whole building.

Carroll Residence Site Inspection

November 19, 1981

General observations were made of the arrangement of electric heaters, the condition of weatherstripping and caulking etc. and specific measurements of temperature and humidity levels throughout the house were taken. Measurements were taken with those instruments used during the first visit and are tabled below.

ROOM	DRY BULB (°F)	WET BULB (°F)	REL. HUM. %	WALL HIGH (°F)	WALL LOW (°F)	BERMED OR UNBERMED	FLOOR(°F)	HEAT ON?	COMMENTS
Entry	68°	57°	50	63	60	unber.	60	Y	fan heater came on just as arriving
Living Room	69°	56.5°	43	67	64	unber.	62	Y	electric baseboard heater on
Dining/Kitchen	69°	57°	47	68	65	berm.	63	N	dishwasher on, hot coffee on stove baseboard on
Family Room	69.5°	57°	56	65	65	berm.	66	Y	electric fan heater blowing down east wall
Bedroom	68.5°	57°	48	67	63	berm.	65	N	
Washroom	70°	58°	48	67	65	berm.	63	N	
Bedroom	70.5°	58°	46	71	65	unber.	65	N	child's bedroom - extra warm baseboard heater just went off
Master Bedroom	69°	58°	51	67	64	berm.	66	N	
Utility	69°	57.5°	49	65	65	berm.	65	N	
Office	69°	57°	47	67	67	berm.	70	N	used as storage space
Guest Room	68.5°	56	45	66	65	unber.	65	N	
Atrium	69°	58.5°	53						
north				65	63				Miscellaneous
south				65	67		64	N	outside air arriving 20.5° leaving 26°
east				68	62				domestic hot water 134°
west				68	65				crawlspace 66°

APPENDIX C

COMPARISON CHART

HOUSE	AIR CHANGE RATE		ENERGY USE		DESIGN LOAD kw	INSULATION			COMMENTS
	@ 4 Pa	@ 50 Pa	kWh/yr	BTU/yr x 10^6		ROOF	WALL	FLOOR	
Carroll Res. (280 m^2)	0.42	2.4	12,768	43.6	7.7	R43	R30 R37 for berm	-	Solar Atrium, Bermed Walls, No Basement Air to Air Heat Exch. Fluorescent Lighting
SEEH (103 m^2)	0.05	1.0	6,600	22.53	4.0	R56	R40 R30 bsmt.	R6 bsmt. flr.	
1980 CEA (103 m^2)	n/a	n/a	21,450	73.2	13.0	R40	R20	-	
1978 MBC (103 m^2)	0.45	3.00	39,600	135.1	24.0	R33	R12 R7 below grade	-	
SCH	0.17	0.8	n/a	n/a	n/a	R60	R40	R40 bsmt.	Solar Collectors, waste water heat reutilization
FH#3 Project (98 m^2)	n/a	0.52	n/a	n/a	4.5	R60	R44	R20 bsmt.	Air to Air Heat Exch.
MECH (199 m^2)	1.04 Psf	n/a	n/a	n/a	10.0	R55	R47 R27 bsmt.	-	10 kw electric furnace

n/a = not available

CHART NO. 1

Comparison of Energy Efficient Homes

APPENDIX D

CALCULATIONS

SURFACE AREAS		Ft^2	M^2	Ratio Area to Total Floor Area
Total Floor		3000	280	1
Atrium Floor		385	36	0.13
Atrium Roof Window		136	12.6	0.045
Total Wall (incl.[9] window)		1776	165	0.6
Exposed Wall (excl.[9] window)		900	84	0.3
Bermed Wall		780	72.5	0.26
Exposed Window		95	8.5	0.032
Total Roof (excl.[9] window)		4285	398	1.43
Ceiling		3000	280	1
Wall Construction:	Outside Air Film		0.17	
	½" plywood		0.62	
	R28 insulation		28.0	R-Value = 30.0
	5/8" drywall		0.53	
	Inside Air Film		0.68	= 30.0
Roof Construction:	Outside Air Film		0.17	
	Cedar Shingles		n/a	
	3/8" plywood		n/a	
	Air Space		n/a	R-Value = 43.38
	R42 insulation		42.0	
	5/8" drywall		0.53	
	Inside Air Film		0.68	
Floor Construction:				
	Ground			
	Air Space		0.91	
	3/4" plywood		0.93	
	½" clay tile or carpet		1.25-2.08	
	Inside Air Film		0.68	

HEAT LOSS STUDY - CARROLL RESIDENCE

Bermed

	U		A		hrs/yr		ΔT		BTU/Yr
Exposed Walls	1/30	x	900	x	5964	x	35.8	:	6,405,336
Bermed Walls	1/37	x	780	x	5964	x	22.625	:	2,844,586
Exposed Wall Windows	1/2.78	x	95	x	5964	x	36.55	:	7,449,100
Exposed Roof Windows	1/2.78	x	136	x	5964	x	43.3	:	12,633,382
Ceiling	1/45.66	x	2864	x	5964	x	38.05	:	14,234,080
Floor (no insulation)	3	x	3000	:					9,000
Total Heat Loss									43,575,484

Not Bermed

	U		A		hrs/yr		ΔT		BTU/Yr
Exposed Walls	1/30	x	1681	x	5964	x	38.05	:	12,715,656
Exposed Wall Windows	1/2.78	x	95	x	5964	x	36.55	:	7,449,100
Exposed Roof Windows	1/2.78	x	136	x	5964	x	43.3	:	12,633,382
Ceiling	1/45.66	x	2864	x	5964	x	38.05	:	14,234,080
Floor (no insulation)	3	x	3000	:					9,000
Total Heat Loss									47,041,218

Bermed Wall Efficiency: 7.3%

Heat Loss: 3,465,734 BTU/Yr. - 1015 KWH/Yr.

APPENDIX E

FIREPLACE INFORMATION

BURNABY
The Fireplace People
2nd & ROSSER BRANDON, MAN.
R7A 0J6 PH. 727-3775

basic energy conservation services, inc.
1296 Hudson Road
St. Paul, MN 55106
774-1362

Minnesota Energy Information Center
Minnesota Energy Agency

980 American Center Building
East Kellogg Boulevard
St. Paul, Minnesota 55101

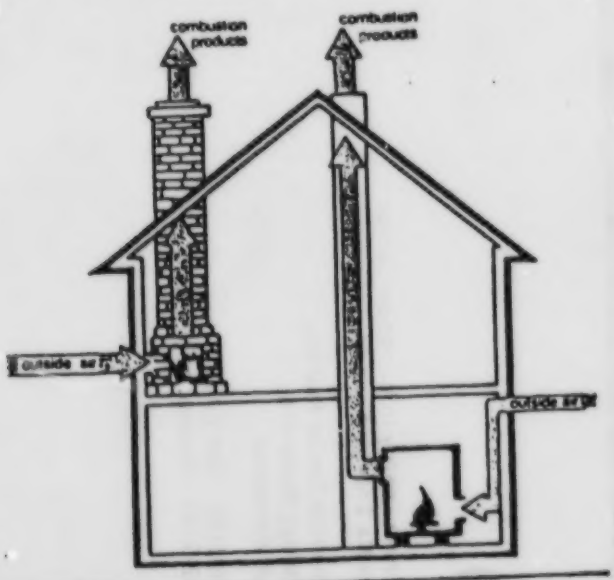
612 296-5175 Twin Cities
800 652-9747 Statewide Toll-free

Good News/Bad News

Weatherstripping and caulking, insulating, and adding storm windows and doors are good conservation measures that save homeowners both energy and money. However, tightening up your house by doing all these things may change the way your furnace or fireplace burns. In fact, doing extensive weatherizing on your home without being sure enough combustion air from outdoors is available can be dangerous. Several tragic deaths have resulted from inadequate combustion air sources in tightly sealed houses.

You should not be discouraged, however, from tightening up your house. Just remember that home conservation measures have *two* parts: for comfort and energy savings, tighten up your home; for safety, provide enough combustion air. (And keep in mind that fireplaces, exhaust fans, clothes dryers, gas stoves and gas water heaters also rob your house of combustion air.)

COMBUSTION AIR CIRCULATION

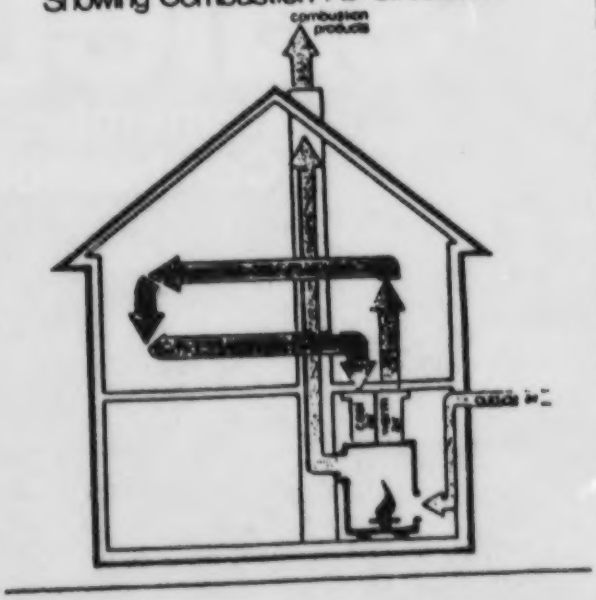


What is Combustion Air?

All fires need air (specifically oxygen) to burn. Furnaces, fireplaces, and woodburning stoves need enough oxygen for *complete* combustion of their fuels. The *incomplete* combustion that takes place when a furnace is "air starved" and not enough oxygen is available causes carbon monoxide (CO) to be formed in quantities that can be dangerous or fatal inside a well-sealed house. Carbon monoxide is odorless and can be deadly in fairly small concentrations. Having a source of combustion air from outside prevents this "air starvation" of the furnace or other fuel burning appliance (if the furnace and flue are also working properly).

Bringing in outside air for combustion has advantages other than health and safety. If the combustion air opening is properly located and properly sized for the home's heating system, outside combustion air can improve furnace efficiency and thereby save energy.

HEATED AIR CIRCULATION (Also Showing Combustion Air Circulation)



It is important not to confuse combustion air circulation with circulation of heated air within the house in a forced air system. Combustion air should go from outdoors through the furnace firebox and up the chimney, carrying off the waste gases. Internal circulating air is moving past the heated firebox chamber and through the house heating ducts.

However, when outside combustion air is not adequate, the furnace may draw air from the house (lowering the amount of oxygen) and exhaust dangerous levels of deadly carbon monoxide back into the house. All parts of the system have to be in order: enough combustion air, well-maintained furnace, and clear (not blocked) chimney.

Why the Problem?

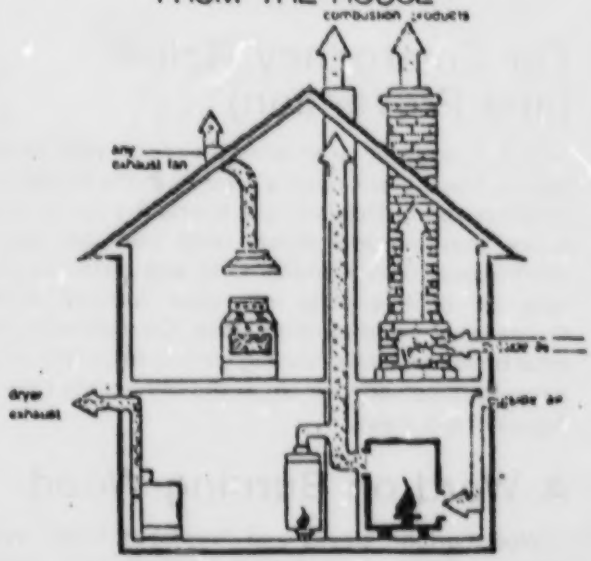
In older homes, enough air leaked in (infiltrated) through the cracks around windows, doors, utility openings, rim joists, and the foundation to provide oxygen for complete combustion of the fuel. This leakage, in most cases, was far in excess of what was needed for combustion air and also caused uncomfortable drafts. Therefore, although the fuel burned well, much energy was wasted. Low fuel costs and large energy supplies kept this from being considered a problem.

Now, of course, homeowners are anxious to change their houses for more efficient (and cheaper) energy use. However, in tightening up a house to save energy (by weatherstripping, caulking, insulating, adding tight storm windows and storm doors), the homeowner may inadvertently reduce infiltrating air below the point needed to provide enough oxygen to the furnace or fireplace.

The problem becomes worse when other kinds of fuel-burning equipment such as fireplaces, wood-burning stoves, gas or oil water heaters, gas stoves, and clothes dryers compete for combustion air.

Using kitchen, bathroom, or attic ventilation fans can also add to the problem. This happens because air is being blown out of the house, and not enough replacement air is coming in to make the furnace draft properly.

APPLIANCES DRAWING AIR FROM THE HOUSE



Do You Have a Problem?

Here are some indicators of inadequate combustion air for homes using different types of fuels:

Oil:

- Chimney smoke is black-colored
- Fuel smell in house
- Soot accumulation
- Popping, banging, or late ignition in furnace

Natural Gas:

- Excessive moisture collecting on windows and walls
- Frequent headaches
- A burning feeling in your nose and eyes
- Gas flame burning yellow rather than blue

Wood:

- Fire smokes and doesn't draft properly even when flue has warmed up

Remember:

- These problems can be caused by fac-

combustion air intake, problems in the fuel burning appliance, or a blocked or inadequate chimney.

For Emergency Relief (and Prevention)

If you suspect a problem, air out your entire house. Then, crack open a window in the furnace or fireplace room. This is only a *temporary* solution, so leave that window open until you get some professional advice and/or help and install an outside air duct directly into your furnace room, fireplace, or wood burning stove. Consult with your local building official, heating contractor, utility company, furnace serviceman, or the Minnesota Energy Agency right away.

A Word on Burning Wood

Woodburning stoves and fireplaces need much more combustion air than a furnace, and should also have outside air ducts. This is *essential* in homes that have gas appliances, for the extremely strong draft from the wood fire can draw gas and combustion products up through the house. Mobile homes also present a critical situation. Any wood burning stove or fireplace should be a "listed" appliance, that is, one with a label stating specifically that it is for use in mobile homes.

A woodburning stove or fireplace should never be left burning at night without a direct source of outside combustion air.

Remember also:

- All home fuel-burning equipment should be inspected by an expert yearly to keep it operating efficiently and properly vented.
- Never use an unvented, fuel burning heater (one without direct connection to a chimney or stack).
- Do not install or use a temporary fuel burning heater without providing an outside combustion air supply.
- Do not use a gas range or oven for heating a room.
- If you have a new house that has an outside combustion air opening to the furnace, never plug it up! You risk your life if you do. If you have a problem with a cold basement floor, get suggestions for solutions from a professional.
- Never use a charcoal grill or hibachi inside. Burning charcoal — whether it's glowing red or turning to gray ashes — gives off large amounts of carbon monoxide.
- If you have a gas heating system, you need a separate chimney or stack for a wood burning stove.

The Bottom Line

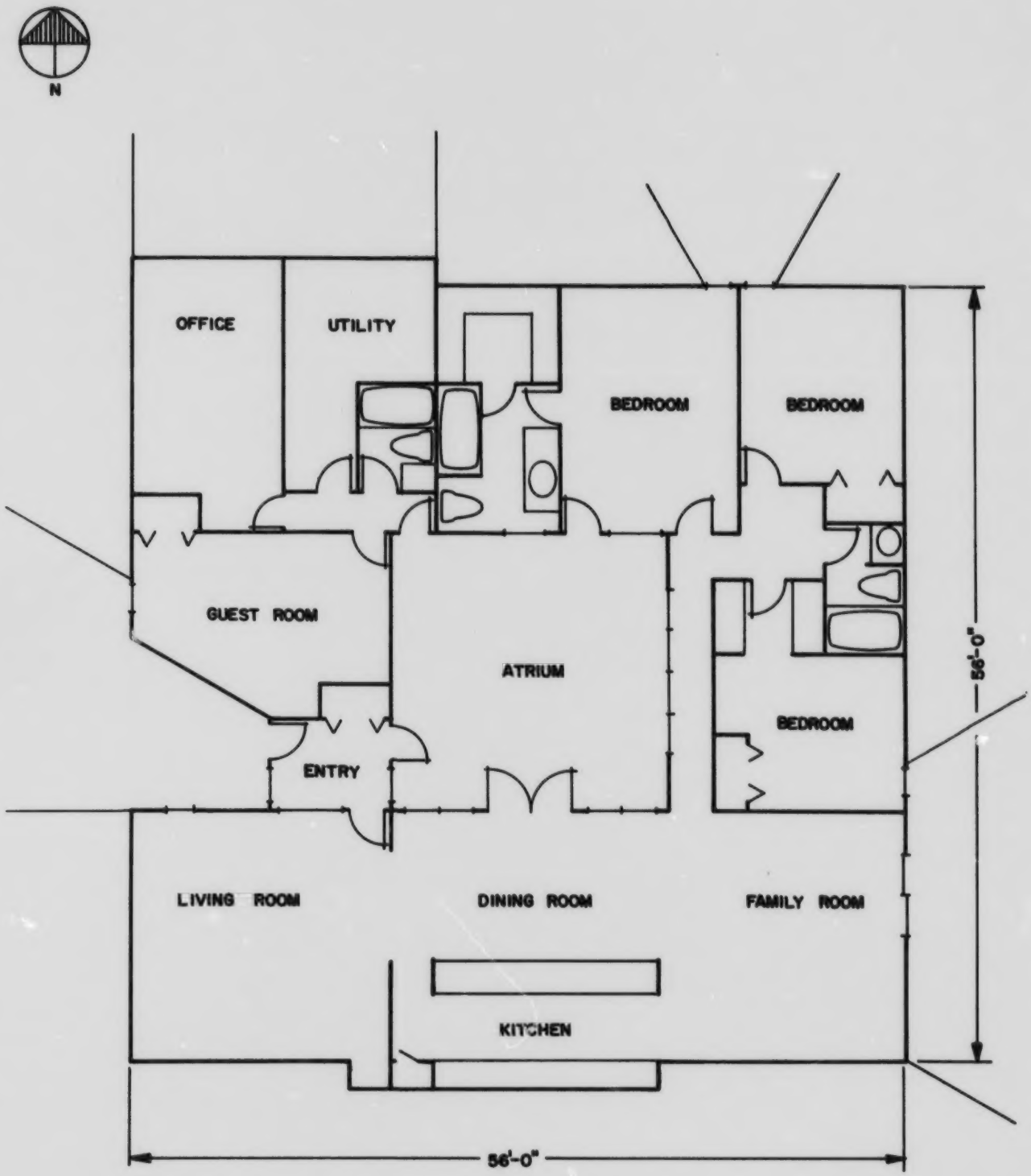
Fixing up your home to save energy can make your home more comfortable to live in, by eliminating drafts and cold walls. It can also save you money. But don't forget that you also change the way your house and heating system "breathe" by doing so. To make sure your furnace — and your family — breathe properly, make sure you balance the conservation changes with combustion air changes.

This pamphlet may be distributed by manufacturers, corporations, organizations, etc. The Minnesota Energy Agency does not endorse specific products or services offered by these organizations.

This pamphlet was produced in cooperation with the Minnesota State Building Code Division.

APPENDIX G

FLOOR PLAN



CARROLL RESIDENCE

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Énergie, Mines et Ressources Canada

MANITOBA

DEPARTMENT OF ENERGY AND MINES

MG-9079